

General Description

The MAX6138 is a precision, two-terminal shunt mode, bandgap voltage reference available in fixed reverse breakdown voltages of 1.2205V, 2.048V, 2.5V, 3.0V, 3.3V, 4.096V, and 5.0V. Ideal for space-critical applications, the MAX6138 is offered in the subminiature 3-pin SC70 surface-mount package (1.8mm X 1.8mm), 50% smaller than comparable devices in SOT23 surfacemount packages.

Laser-trimmed resistors ensure precise initial accuracy. With a 25ppm/°C temperature coefficient, the device is offered in three grades of initial accuracy ranging from 0.1% to 0.5%. The MAX6138 has a 60µA to 15mA shuntcurrent capability with low-dynamic impedance, ensuring stable reverse breakdown voltage accuracy over a wide range of operating temperatures and currents.

The MAX6138 does not require an external stabilizing capacitor while ensuring stability with capacitive loads. The MAX6138 is a higher precision device in a smaller package than the LM4040/LM4050.

Applications

Portable, Battery-Powered Equipment Notebook Computers Cell Phones Industrial Process Control

Features

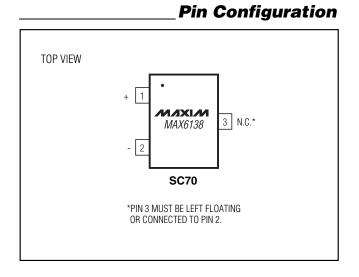
- ♦ Ultra-Small 3-Pin SC70 Package
- ♦ 0.1% (max) Initial Accuracy
- ◆ 25ppm/°C (max) Temperature Coefficient Guaranteed Over -40°C to +85°C Temperature
- ♦ Wide Operating Current Range: 60µA to 15mA
- ♦ Low 28µV_{RMS} Output Noise (10Hz to 10kHz)
- ♦ 1.2205V, 2.048V, 2.5V, 3.0V, 3.3V, 4.096V, and 5.0V **Fixed Reverse Breakdown Voltages**
- ♦ No Output Capacitors Required
- ♦ Stable with Capacitive Loads

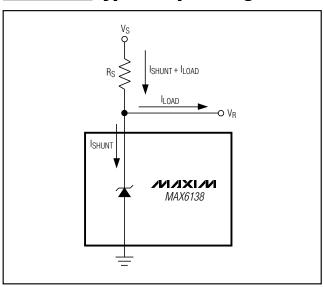
Selector Guide

PART	TEMP RANGE	PIN- PACKAGE	OUTPUT VOLTAGE (V)
MAX6138_EXR12-T	-40°C to +85°C	3 SC70-3	1.2205
MAX6138_EXR21-T	-40°C to +85°C	3 SC70-3	2.0480
MAX6138_EXR25-T	-40°C to +85°C	3 SC70-3	2.5000
MAX6138_EXR30-T	-40°C to +85°C	3 SC70-3	3.0000
MAX6138_EXR33-T	-40°C to +85°C	3 SC70-3	3.3000
MAX6138_EXR41-T	-40°C to +85°C	3 SC70-3	4.0960
MAX6138_EXR50-T	-40°C to +85°C	3 SC70-3	5.0000

Ordering Information appears at end of data sheet.

Typical Operating Circuit





MIXIM

Maxim Integrated Products 1

ABSOLUTE MAXIMUM RATINGS

Reverse Current (cathode to anode)	20mA
Forward Current (anode to cathode)	10mA
Continuous Power Dissipation (T _A = +70°C)	
3-Pin SC70 (derate 2.17mW/°C above +70°C)	174mW

Operating Temperature Range	40°C to +125°C
Storage Temperature Range	65°C to +150°C
Junction Temperature	+150°C
Lead Temperature (soldering, 1	10s)+300°C

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS—MAX6138_12 (1.2205V)

 $(I_R = 100\mu A, T_A = -40^{\circ}C \text{ to } +85^{\circ}C, \text{ unless otherwise noted. Typical values are at } T_A = +25^{\circ}C.)$ (Note 1)

PARAMETER	SYMBOL	CC	ONDITIONS	MIN	TYP	MAX	UNITS
			MAX6138A (0.1%)	1.2193	1.2205	1.2217	
Reverse Breakdown Voltage (Note 2)	VR	T _A = +25°C	MAX6138B (0.2%)	1.2181	1.2205	1.2229	V
(Note 2)			MAX6138C (0.5%)	1.2144	1.2205	1.2266	
Minimum Operating Current	I _{RMIN}				45	60	μΑ
Reverse Voltage Temperature Coefficient (Notes 2, 3)	TC				4	25	ppm/°C
Reverse Breakdown Voltage		I _{RMIN} ≤ I _R ≤ 1m	nA		0.3	1.0	
Change with Operating Current Change	$\Delta V_R/\Delta I_R$	1mA ≤ I _R ≤ 12n	nA		2.5	8.0	mV
Reverse Dynamic Impedance (Note 3)	Z _R	I _R = 1mA, f = 120Hz, I _{AC} = 0.1I _R			0.3	0.8	Ω
Wideband Noise	eN	$I_R = 10\mu A$, $10Hz \le f \le 10kHz$			20		μV _{RMS}
Reverse Breakdown Voltage	ΔV_{R}	t = 1000h			120		ppm

ELECTRICAL CHARACTERISTICS—MAX6138_21 (2.048V)

 $(I_R = 100 \mu A, T_A = -40 ^{\circ} C \text{ to } +85 ^{\circ} C, \text{ unless otherwise noted. Typical values are at } T_A = +25 ^{\circ} C.)$ (Note 1)

PARAMETER	SYMBOL	C	ONDITIONS	MIN	TYP	MAX	UNITS
			MAX6138A (0.1%)	2.0460	2.0480	2.0500	
Reverse Breakdown Voltage (Note 2)	V_{R}	$T_A = +25^{\circ}C$	MAX6138B (0.2%)	2.0439	2.0480	2.0521	V
Voltage (1vote 2)			MAX6138C (0.5%)	2.0378	2.0480	2.0582	
Minimum Operating Current	I _{RMIN}				45	65	μΑ
Reverse Voltage Temperature Coefficient (Notes 2, 3)	TC				4	25	ppm/°C
Reverse Breakdown Voltage Change with	ΔV _R /Δl _R	I _{RMIN} ≤ I _R ≤ 1m	nA		0.3	1.0	mV
Operating Current Change	AVR/AIR	1mA ≤ I _R ≤ 15n	mA		2.5	8.0	1111
Reverse Dynamic Impedance (Note 3)	Z _R	$I_R = 1 \text{mA}, f = 1$	I _R = 1mA, f = 120Hz, I _{AC} = 0.1I _R		0.3	0.8	Ω
Wideband Noise	eN	10Hz ≤ f ≤ 10kHz			28		μV _{RMS}
Reverse Breakdown Voltage Long-Term Stability	ΔV_{R}	t = 1000h			120		ppm

ELECTRICAL CHARACTERISTICS—MAX6138_25 (2.5V)

 $(I_R = 100 \mu A, T_A = -40 ^{\circ}C \text{ to } +85 ^{\circ}C, \text{ unless otherwise noted. Typical values are at } T_A = +25 ^{\circ}C.)$ (Note 1)

PARAMETER	SYMBOL	С	ONDITIONS	MIN	TYP	MAX	UNITS
			MAX6138A (0.1%)	2.4975	2.5000	2.5025	
Reverse Breakdown Voltage (Note 2)	V_{R}	$T_A = +25^{\circ}C$	MAX6138B (0.2%)	2.4950	2.5000	2.5050	V
(Note 2)			MAX6138C (0.2%)	2.4875	2.5000	2.5125	
Minimum Operating Current	I _{RMIN}				45	65	μΑ
Reverse Voltage Temperature Coefficient (Notes 2, 3)	TC				4	25	ppm/°C
Reverse Breakdown Voltage Change with Operating Current Change	$\Delta V_{ m R}/\Delta I_{ m R}$	I _{RMIN} ≤ I _R ≤ 1m	nA		0.3	1.0	mV
Reverse Breakdown Voltage Change with Operating Current Change	$\Delta V_{ m R}/\Delta I_{ m R}$	1mA ≤ I _R ≤ 15r	nA		2.5	8.0	mV
Reverse Dynamic Impedance (Note 3)	Z _R	I _R = 1mA, f = 1	I _R = 1mA, f = 120Hz, I _{AC} = 0.1I _R		0.3	0.8	Ω
Wideband Noise	eN	10Hz ≤ f ≤ 10kHz			35		μVRMS
Reverse Breakdown Voltage Long-Term Stability	ΔV_{R}	t = 1000h			120		ppm

ELECTRICAL CHARACTERISTICS—MAX6138_30 (3.0V)

 $(I_R = 100 \mu A, T_A = -40 ^{\circ} C \text{ to } +85 ^{\circ} C, \text{ unless otherwise noted. Typical values are at } T_A = +25 ^{\circ} C.)$ (Note 1)

PARAMETER	SYMBOL	cc	ONDITIONS	MIN	TYP	MAX	UNITS
			MAX6138A (0.1%)	2.9970	3.0000	3.0030	
Reverse Breakdown	VR	T _A = +25°C	MAX6138B (0.2%)	2.9940	3.0000	3.0060	V
Voltage (Note 2)			MAX6138C (0.5%)	2.9850	3.0000	3.0150	
Minimum Operating Current	I _{RMIN}				45	65	μΑ
Reverse Voltage Temperature Coefficient (Notes 2, 3)	TC				4	25	ppm/°C
Reverse Breakdown	A)/ /AI	I _{RMIN} ≤ I _R ≤ 1m	nA		0.3	1.0	>/
Voltage Change with Operating Current Change	$\Delta V_R/\Delta I_R$	1mA ≤ I _R ≤ 15mA			2.5	8.0	mV
Reverse Dynamic Impedance (Note 3)	Z _R	I _R = 1mA, f = 12	20Hz, I _{AC} = 0.1I _R		0.3	0.8	Ω
Wideband Noise	eN	10Hz ≤ f ≤ 10kł	-lz		45		μV _{RMS}
Reverse Breakdown Voltage Long-Term Stability	ΔV_{R}	t = 1000h			120		ppm

ELECTRICAL CHARACTERISTICS—MAX6138_33 (3.3V)

 $(I_R = 100\mu A, T_A = -40^{\circ}C \text{ to } +85^{\circ}C, \text{ unless otherwise noted. Typical values are at } T_A = +25^{\circ}C.)$ (Note 1)

PARAMETER	SYMBOL	cc	NDITIONS	MIN	TYP	MAX	UNITS
	V _R		MAX6138A (0.1%)	3.2967	3.3000	3.3033	
Reverse Breakdown Voltage (Note 2)		T _A = +25°C	MAX6138B (0.2%)	3.2934	3.3000	3.3066	V
Voltage (Note 2)			MAX6138C (0.5%)	3.2835	3.3000	3.3165	
Minimum Operating Current	I _{RMIN}				45	67	μΑ
Reverse Voltage Temperature Coefficient (Notes 2, 3)	TC				4	25	ppm/°C
Reverse Breakdown Voltage Change with	ΔV _R /Δl _R	I _{RMIN} ≤ I _R ≤ 1m	nA		0.3	1.0	mV
Operating Current Change	Δν Κ/ΔιΚ	1mA ≤ I _R ≤ 15n	$1mA \le I_R \le 15mA$			8.0	IIIV
Reverse Dynamic Impedance (Note 3)	Z _R	$I_R = 1 \text{mA}, f = 12$	20 Hz, $I_{AC} = 0.1I_{R}$		0.3	0.8	Ω
Wideband Noise	eN	10Hz ≤ f ≤ 10kH	Hz		50		μV _{RMS}
Reverse Breakdown Voltage Long-Term Stability	ΔV_{R}	t = 1000h			120		ppm

ELECTRICAL CHARACTERISTICS—MAX6138_41 (4.096V)

 $(I_R = 100 \mu A, T_A = -40 ^{\circ} C \text{ to } +85 ^{\circ} C, \text{ unless otherwise noted. Typical values are at } T_A = +25 ^{\circ} C.)$ (Note 1)

PARAMETER	SYMBOL	CON	IDITIONS	MIN	TYP	MAX	UNITS
			MAX6138A (0.1%)	4.0919	4.0960	4.1001	
Reverse Breakdown Voltage (Note 2)	VR	T _A = +25°C	MAX6138B (0.2%)	4.0878	4.0960	4.1042	V
Voltage (Note 2)			MAX6138C (0.5%)	4.0755	4.0960	4.1165	
Minimum Operating Current	IRMIN				50	73	μА
Reverse Voltage Temperature Coefficient (Notes 2, 3)	TC				4	25	ppm/°C
Reverse Breakdown Voltage Change with	ΔVR/ΔIR	I _{RMIN} ≤ I _R ≤ 1mA	A		0.5	1.2	mV
Operating Current Change	ΔV Π/ΔΙΠ	1mA ≤ I _R ≤ 15mA	$1mA \le I_R \le 15mA$		3.0	10.0	1110
Reverse Dynamic Impedance (Note 3)	ZR	I _R = 1mA, f = 12	0Hz, I _{AC} = 0.1I _R		0.5	1.0	Ω
Wideband Noise	eΝ	10Hz ≤ f ≤ 10kHz	7		64		μV _{RMS}
Reverse Breakdown Voltage Long-Term Stability	ΔVR	t = 1000h			120		ppm

ELECTRICAL CHARACTERISTICS—MAX6138_50 (5.0V)

 $(I_R = 100\mu A, T_A = -40^{\circ}C \text{ to } +85^{\circ}C, \text{ unless otherwise noted. Typical values are at } T_A = +25^{\circ}C.)$ (Note 1)

PARAMETER	SYMBOL	COI	NDITIONS	MIN	TYP	MAX	UNITS
			MAX6138A (0.1%)	4.9950	5.0000	5.0050	
Reverse Breakdown Voltage (Note 2)	V_{R}	$T_A = +25^{\circ}C$	MAX6138B (0.2%)	4.9900	5.0000	5.0100	V
Voltage (1vote 2)			MAX6138C (0.5%)	4.9750	5.0000	5.0250	
Minimum Operating Current	I _{RMIN}				54	80	μΑ
Reverse Voltage Temperature Coefficient (Notes 2, 3)	TC				4	25	ppm/°C
Reverse Breakdown	A\/=/A\=	I _{RMIN} ≤ I _R ≤ 1m/	4		0.5	1.4	mV
Voltage Change with Operating Current Change	$\Delta V_{ m R}/\Delta I_{ m R}$	1mA ≤ I _R ≤ 15mA			3.5	12.0	IIIV
Reverse Dynamic Impedance (Note 3)	Z _R	I _R = 1mA, f = 12	20Hz, I _{AC} = 0.1I _R		0.5	1.1	Ω
Wideband Noise	eN	10Hz ≤ f ≤ 10kH	Z		80		μV _{RMS}
Reverse Breakdown Voltage Long-Term Stability	ΔV_{R}	t = 1000h			120		ppm

Note 1: All devices are 100% production tested at +25°C and are guaranteed by correlation for TA = TMAX to TMIN, as specified.

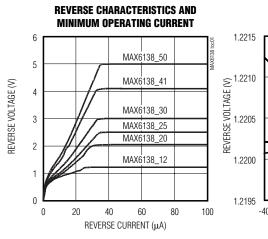
Note 2: TC is measured by the "box" method, i.e. (VMAX - VMIN) / (TMAX - TMIN)

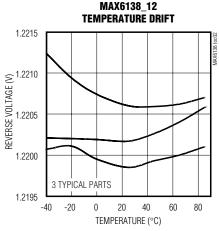
Note 3: Guaranteed by design.

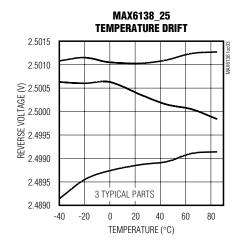


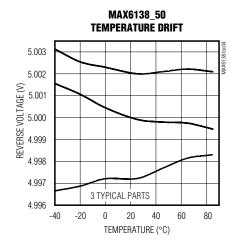
Typical Operating Characteristics

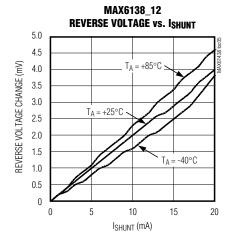
 $(I_R = 100\mu A, T_A = +25^{\circ}C, \text{ unless otherwise noted.})$





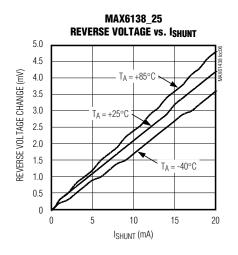


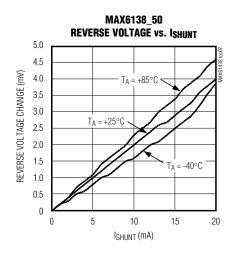


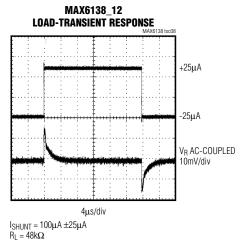


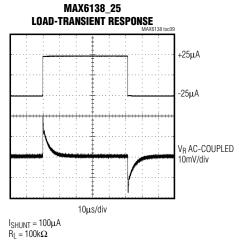
Typical Operating Characteristics (continued)

($I_R = 100\mu A$, $T_A = +25^{\circ}C$, unless otherwise noted.)









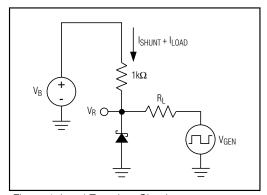
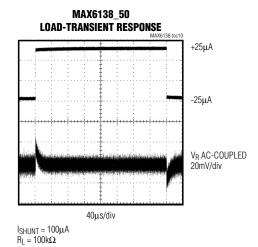
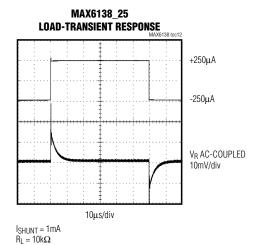


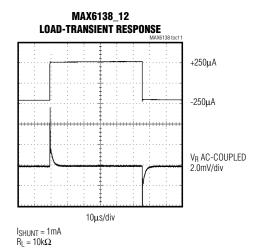
Figure 1. Load-Transient Circuit

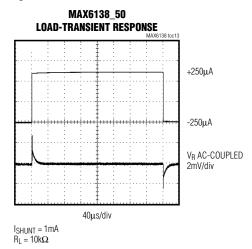
Typical Operating Characteristics (continued)

 $(I_R = 100\mu A, T_A = +25^{\circ}C, \text{ unless otherwise noted.})$









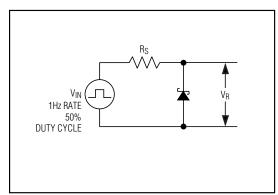
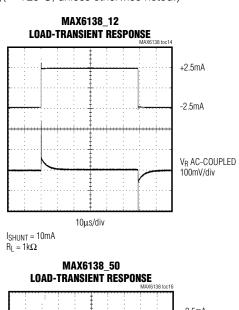
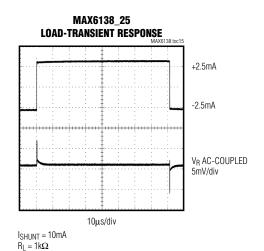


Figure 2. Startup Characteristics Test Circuit

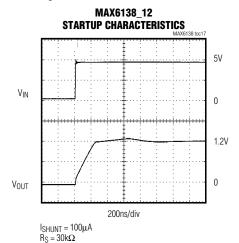
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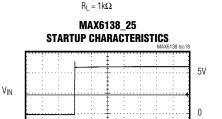
 $(I_R = 100\mu A, T_A = +25^{\circ}C, \text{ unless otherwise noted.})$





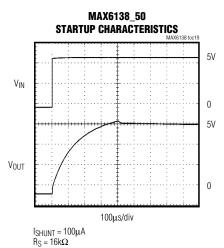
40µs/div

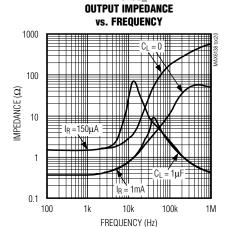




2us/div

 $I_{SHUNT} = 10 \text{mA}$





MAX6138 12

2V

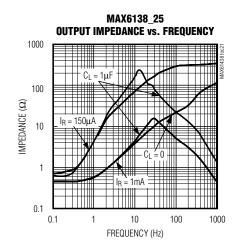
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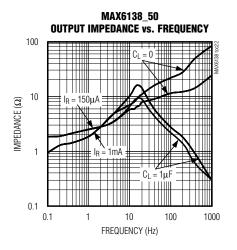
 $\begin{aligned} I_{SHUNT} &= 100 \mu A \\ R_S &= 30 k \Omega \end{aligned}$

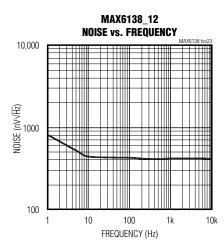
Vout

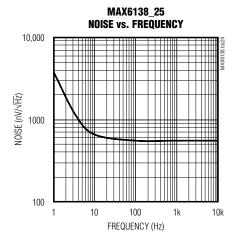
Typical Operating Characteristics (continued)

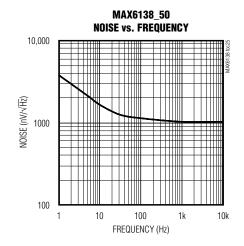
 $(I_R = 100\mu A, T_A = +25^{\circ}C, \text{ unless otherwise noted.})$











Pin Description

PIN	NAME	FUNCTION
1	+	Positive Terminal of the Shunt Reference
2	-	Negative Terminal of the Shunt Reference
3	N.C.	No Connection. Leave this pin unconnected or connect to Pin 2.

Detailed Description

The MAX6138 shunt reference uses the bandgap principle to produce a stable, accurate voltage. The device behaves similarly to an ideal zener diode; a fixed voltage is maintained across its output terminals when biased with $60\mu A$ to 15mA of reverse current. The MAX6138 behaves similarly to a silicon diode when biased with forward currents up to 10mA.

Figure 3 shows a typical operating circuit. The MAX6138 is ideal for providing a stable reference from a high-voltage power supply.

_Applications Information

The MAX6138's internal pass transistor is used to maintain a constant output voltage (VSHUNT) by sinking the necessary amount of current across a source resistor. The source resistance (RS) is determined from the load current (ILOAD) range, supply voltage (VS) variations, VSHUNT, and desired quiescent current.

Choose the value of Rs when Vs is at a minimum and I_{LOAD} is at a maximum. Maintain a minimum I_{SHUNT} of $60\mu\text{A}$ at all times. The Rs value should be large enough to keep I_{SHUNT} less than 15mA for proper regulation when Vs is maximum and I_{LOAD} is at a minimum. To prevent damage to the device, I_{SHUNT} should never exceed 20mA.

Therefore, the value of Rs is bounded by the following equation:

 $[V_{S(MIN)} - V_{R}] / [60\mu A + I_{LOAD(MAX)}] > R_{S} >$

 $[V_{S(MAX)} - V_{R}] / [20mA + I_{LOAD(MIN)}]$

Choosing a larger resistance minimizes the total power dissipation in the circuit by reducing the shunt current (PD(TOTAL) = VS X ISHUNT). Provide a safety margin to incorporate the worst-case tolerance of the resistor used. Ensure that the resistor's power rating is adequate, using the following general power equation:

PDR = ISHUNT × (VS(MAX) - VSHUNT)

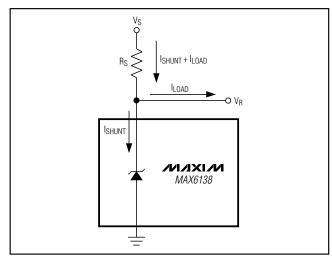


Figure 3. Typical Operating Circuit

Output Capacitance

The MAX6138 does not require an external capacitor for operational stability and is stable for any output capacitance.

Temperature Performance

The MAX6138 typically exhibits an output voltage temperature coefficient within ±4ppm/°C. The polarity of the temperature coefficient may be different from one device to another; some may have positive coefficients, and others may have negative coefficients.

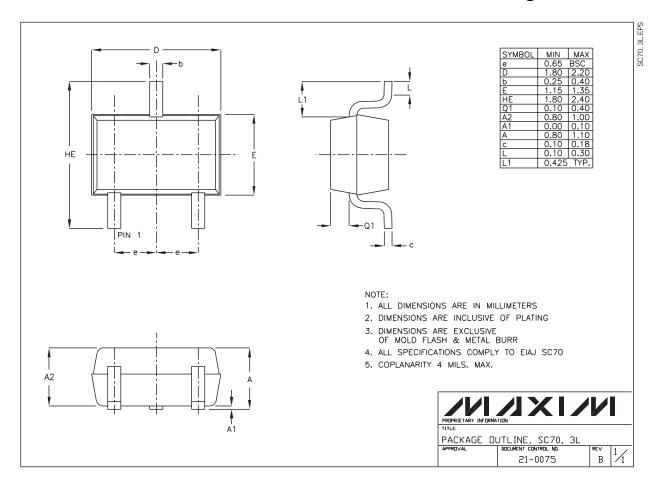
_Chip Information

TRANSISTOR COUNT: 70 PROCESS: BICMOS

Ordering Information

PART	OUTPUT VOLTAGE (V)	INITIAL ACCURACY (%)	TEMP RANGE	PIN-PACKAGE	TOP MARK
MAX6138AEXR12-T	1.2205	0.1	-40°C to +85°C	3 SC70-3	AEW
MAX6138BEXR12-T	1.2205	0.2	-40°C to +85°C	3 SC70-3	AEX
MAX6138CEXR12-T	1.2205	0.5	-40°C to +85°C	3 SC70-3	AEY
MAX6138AEXR21-T	2.0480	0.1	-40°C to +85°C	3 SC70-3	AFA
MAX6138BEXR21-T	2.0480	0.2	-40°C to +85°C	3 SC70-3	AFB
MAX6138CEXR21-T	2.0480	0.5	-40°C to +85°C	3 SC70-3	AFC
MAX6138AEXR25-T	2.5000	0.1	-40°C to +85°C	3 SC70-3	AFE
MAX6138BEXR25-T	2.5000	0.2	-40°C to +85°C	3 SC70-3	AFF
MAX6138CEXR25-T	2.5000	0.5	-40°C to +85°C	3 SC70-3	AFG
MAX6138AEXR30-T	3.0000	0.1	-40°C to +85°C	3 SC70-3	AFI
MAX6138BEXR30-T	3.0000	0.2	-40°C to +85°C	3 SC70-3	AFJ
MAX6138CEXR30-T	3.0000	0.5	-40°C to +85°C	3 SC70-3	AFK
MAX6138AEXR33-T	3.3000	0.1	-40°C to +85°C	3 SC70-3	ANG
MAX6138BEXR33-T	3.3000	0.2	-40°C to +85°C	3 SC70-3	ANH
MAX6138CEXR33-T	3.3000	0.5	-40°C to +85°C	3 SC70-3	ANI
MAX6138AEXR41-T	4.0960	0.1	-40°C to +85°C	3 SC70-3	AFM
MAX6138BEXR41-T	4.0960	0.2	-40°C to +85°C	3 SC70-3	AFN
MAX6138CEXR41-T	4.0960	0.5	-40°C to +85°C	3 SC70-3	AFO
MAX6138AEXR50-T	5.0000	0.1	-40°C to +85°C	3 SC70-3	AFQ
MAX6138BEXR50-T	5.0000	0.2	-40°C to +85°C	3 SC70-3	AFR
MAX6138CEXR50-T	5.0000	0.5	-40°C to +85°C	3 SC70-3	AFS

Package Information



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